him as analogous to the apical fibres of *Polysiphoniæ*, described by Dr. Harvey.

Rev. Samuel Haughton communicated to the Academy an account of the late Professor Mac Cullagh's lectures on the rotation of a solid body round a fixed point, compiled from notes of his lectures.

The Secretary read a paper by Mr. Henry Henessy, "On the Influence of the Earth's figure on the Distribution of Land and Water at its Surface."

" In a paper, read before the Geological Society of Dublin, on the Changes of the Earth's Figure and Climate, resulting from causes acting at its surface, the author endeavoured to show that certain phenomena, which in some quarters were supposed to be explicable by appealing to such causes, are not at all capable of being so explained. In support of this conclusion it was stated that if, in accordance with the assumptions of the theory considered in the paper alluded to, the earth were originally a solid sphere, and if the ratio of its mean equatorial to its mean polar radius continually increased, the area of dry land at the equator, compared to its area at the poles, would also continually increase.

" To the author this proposition appeared so evident that he did not think its formal proof required to be exhibited. As, however, it subsequently seemed desirable that such a proof should be produced, he has attempted in this paper to fulfil that object.

" Besides proving the proposition in question, the author believes that he has arrived at a new result, which alone would support the views he advocated in the paper already cited.

" 1. If, in accordance with the fundamental assumptions of the theory considered in the paper referred to, the earth

were originally a solid sphere, composed of concentric spherical strata of equal density, and covered with the water which now constitutes its seas and oceans, it is evident that its rotation would tend to give a spheroidal form to the surface of the fluid. If, by the action of causes at the surface of the earth, the solid sphere became gradually an oblate spheroid, the direction of the resultant of the forces acting on a particle of the fluid at its surface would be also gradually changed, and consequently the form of the surface. The distribution of the water on the earth's surface might thus be so altered as to tend in some regions to lay bare the former bed of the ocean, and in others to submerge the dry land. The following investigation shows that such a tendency would exist, and, moreover, that it would be such as to establish the truth of the proposition stated in the foregoing introductory remarks.

"2. As the causes by which the surface of the earth may have acquired a spheroidal form are assumed to act only at its surface, it follows that, except in the immediate vicinity of that surface, its constitution must remain unchanged. It will, therefore, consist of a sphere composed of concentric spherical strata surrounded by a solid mass, having its mean density equal to that of the surface stratum of the sphere, and included between a spherical and spheroidal surface, together with the fluid mass covering the latter. The surface of the fluid being spheroidal, and the surface bounding the exterior solid mass having necessarily a small ellipticity, we may suppose that of the former surface small. In the succeeding investigation the second powers of these ellipticities shall therefore be neglected.

"The forces acting on a particle at the surface of the fluid in equilibrium are:

"(1.) Attraction of the solid sphere with the radius a_2 and mean density D.

"(2.) *Attraction of the superficial mass with the density* D_1, bounded inwardly by the spherical surface with the radius

a_2, and outwardly by the spheroidal surface with the mean radius a_1.

" (3.) Attraction of the mass of fluid bounded inwardly by the spheroidal surface having the mean radius a_1, and outwardly by the spheroidal surface, having the mean radius a.

" (4.) Centrifugal force.

" If U_0, U_1, U_2, &c., represent such functions of the coordinates of the spheroid, that on the substitution of each successively for U_i in the following well-known differential equation it will be satisfied,

$$\frac{d \, . \sin\theta \dfrac{dU_i}{d\theta}}{\sin\theta d\theta} + \frac{1}{\sin^2\theta}\frac{d^2 U_i}{d\omega^2} + r\frac{d^2 r U_i}{dr^2} = 0\,;$$

and if we use the notation of M. de Pontécoulant for all quantities not otherwise specified, we shall have, for the functions on which the forces above enumerated depend,*

$$\left.\begin{array}{ll}
(1) & \dfrac{4\pi a_2{}^3 D}{3r} \\
(2) & \dfrac{4\pi}{3r}(a_1{}^3 - a_2{}^3)D_1 + \dfrac{4\pi D_1 \alpha_1 a_1{}^3}{r}\left(\dfrac{a_1{}^2}{5r^2}U_2 + \dfrac{a_1{}^3}{7r^3}U_3 + \&c.\right) \\
(3) & \dfrac{4\pi}{3r}(a^3 - a_1{}^3) + \dfrac{4\pi}{r}\left\{\alpha a^3\left(\dfrac{a^2}{5r^2}Y_2 + \dfrac{a^3}{7r^3}Y_3 + \&c.\right)\right. \\
 & \qquad\qquad \left. - \alpha_1 a_1{}^3\left(\dfrac{a_1{}^2}{5r^2}U_2 + \dfrac{a_1{}^3}{7r^3}U_3 + \&c.\right)\right\} \\
(4) & \tfrac{1}{3}gr^2 - \tfrac{1}{2}gr^2(\cos^2\theta - \tfrac{1}{3}).
\end{array}\right\}\ (a)$$

U_0, U_1, Y_0, Y_1, being omitted by the properties of such functions,† and α_1 being a small quantity depending on the ellipticity of the spheroidal surface bounding the solid mass. The equation of equilibrium of the fluid surface will therefore be

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* Pontécoulant, Theorie Analytique du Systeme du Monde, livre v. No. 32.

† Ibid.

$$C = \frac{4\pi}{3r}\{a^3 + a_1^3(D_1 - 1) + a_2^3(D - D_1)\}$$

$$+ \frac{4\pi}{r}\left\{aa^3\left(\frac{a^2}{5r^2}Y_2 + \frac{a^3}{7r^3}Y_3 + \&c.\right)\right.$$

$$\left. + a_1a_1^3(D_1 - 1)\left(\frac{a_1^2}{5r^2}U_2 + \frac{a_1^3}{7r^3}U_3 + \&c.\right)\right\}$$

$$+ \tfrac{1}{3}gr^2 - \tfrac{1}{2}gr^2(\cos^2\theta - \tfrac{1}{3}),$$

C being an arbitrary constant.

But r, the radius of the surface of the fluid, $= a(1 + ay)$, and by hypothesis $a - a_1$, $a_1 - a_2$, are small quantities; hence, if r be developed, and all small quantities of the second order be neglected, we shall have, remembering that C is arbitrary,

$$C = \frac{4\pi a^2}{3}\left(1 + \frac{a_1^3}{a^3}(D_1 - 1) + \frac{a_2^3}{a^3}(D - D_1)\right) + \tfrac{1}{3}ga^2,$$

and

$$+ \frac{4\pi Da^2a}{3}y - 4\pi\{aa^2(\tfrac{1}{5}Y_2 + \tfrac{1}{7}Y_3 + \&c.)$$

$$+ a_1a_1^2(D_1 - 1)(\tfrac{1}{5}U_2 + \tfrac{1}{7}U_3 + \&c.)\}$$

$$+ \tfrac{1}{2}ga^2(\cos^2\theta - \tfrac{1}{3}) = 0.$$

"By a process exactly similar to that performed in the work referred to, and remembering the assumption of the theory, I find for the solid spheroid, $U_3 = 0$, $U_4 = 0$, and in general $U_i = 0$, when i is not 2, and $a_1 U_2 = - e_1(\cos^2\theta - \tfrac{1}{3})$; e_1 representing the ellipticity of the spheroid. Hence

$$ay = \frac{3aY_2}{5D} + \frac{3a}{D}(\tfrac{1}{7}Y_3 + \&c.)$$

$$- \left(\frac{3(D_1 - 1)}{5D}e_1 + \tfrac{1}{2}\frac{g}{\frac{4}{3}\pi D}\right)(\cos^2\theta - \tfrac{1}{3}).$$

But also

$$y = Y_2 + Y_3 + Y_4 + \dots Y_i.$$

Hence, comparing terms of the same order in these expressions, we obtain

$$Y_3 = 0, \quad Y_4 = 0, \ldots \; Y_i = 0,$$

$$a\,Y_2 = \frac{3\,a\,Y_2}{5D} - \left(\frac{3\,(D_1 - 1)}{5D}\,e_1 + \tfrac{1}{2}q\right)(\cos^2\theta - \tfrac{1}{3}),$$

or

$$a\,Y_2 = -\left(\frac{6\,(D_1 - 1)\,e_1 + 5\,qD}{2\,(5D - 3)}\right)(\cos^2\theta - \tfrac{1}{3});$$

and, therefore,

$$r = a\left\{1 - \left(\frac{5qD + 6\,(D_1 - 1)\,e_1}{2\,(5D - 3)}\right)(\cos^2\theta - \tfrac{1}{3})\right\}. \quad \text{(b)}$$

This is an expression for the radius of a spheroidal surface of revolution having the ellipticity

$$\frac{5qD + 6\,(D_1 - 1)\,e_1}{2\,(5D - 3)}.$$

" 3. If the difference between the ellipticities of the spheroid bounding the fluid, and that bounding the solid mass, be represented by ε, we shall have

$$\varepsilon = \frac{5qD - 2\,(5D - 3D_1)\,e_1}{2\,(5D - 3)}. \quad \text{(c)}$$

This expression shows, that when $5D > 3D_1$, ε will decrease when e_1 increases. In the actual case of the earth we should have $D = 2D_1$ nearly, and consequently

$$\varepsilon = \frac{(5q - 7e_1)\,D_1}{(5D - 3)}.$$

ε cannot be negative, and if it become zero, $e_1 = \frac{5q}{7}$. But q being the ratio of centrifugal force to gravity at the equator, and, therefore, its value being $\frac{1}{289}$, we should have the ellipticity finally attained by the earth, from the action of superficial causes, equal to $\frac{1}{404.6}$. This quantity is, however, too small to be admissible, and, consequently, the above result

alone furnishes a conclusive argument against the theory considered.

"It manifestly follows, from the value which has been found for ε, that if e_1 were small, the waters would tend to accumulate about the equatorial regions; and if, on the contrary, e_1 were large, they would tend to accumulate about the polar regions. If, therefore, from any superficial causes, the earth's figure became gradually more oblate, the extent of polar dry land would gradually tend to lessen, while that of the equatorial regions would at the same time tend to increase. The truth of our fundamental proposition cannot, therefore, admit of any further doubt.

"4. It may be useful to give still greater force to these conclusions by some additional considerations. With the supposed original spherical figure of the earth, the circumambient fluid would, as already remarked, assume, by the action of centrifugal force, a spheroidal form. The fluid would thus tend to accumulate towards the equator, and to recede from the poles. Circumpolar continents might thus be formed, with a great equatorial ocean between them. Some of the foregoing expressions will assist in determining the conditions of the existence of such continents.

"Let θ_1 represent the complement of the latitude at the parallel bounding a circumpolar continent on the surface of the primitive sphere, then the area of this continent will be

$$\tfrac{1}{2}(1 - \cos\theta_1),$$

the area of the sphere being unity. But at that parallel $r = a_1$, and, therefore,

$$a_1 = a\left(1 - \frac{5qD}{2(5D-3)}\left(\cos^2\theta - \tfrac{1}{3}\right)\right),$$

making $e_1 = 0$ in (b). Hence

$$\cos\theta_1 = \pm\sqrt{\left(\tfrac{1}{3} + \frac{2(a-a_1)(5D-3)}{5qDa}\right)}.$$

Let δ represent the present mean depth of the sea; L and W the areas of dry land and water, as determined by observation; then as $a - a_1$ is evidently the mean depth of the fluid covering the sphere supposed at rest,

$$\frac{a - a_1}{\delta} = \frac{W}{L + W}, \text{ or } \delta = (a - a_1)\left(1 + \frac{L}{W}\right),$$

$$\cos\theta_1 = \sqrt{\left(\tfrac{1}{3} + \frac{2\delta(5D - 3)}{5qDa\left(1 + \frac{L}{W}\right)}\right)}.$$

By observation,

$$D = 5.5, \quad q = \frac{1}{289}, \quad \frac{L}{W} = \frac{266}{734}.$$

"If, as is generally supposed, the mean depth of the sea be proportional to the mean height of the land above its surface in the relation of their respective areas, the greatest value which can be attributed to $\frac{\delta}{a}$ would be $\frac{1}{4000}$, or a mile nearly. Then

$$\cos\theta_1 = \sqrt{\left(\tfrac{1}{3} + \frac{24.5 \times 289 \times 734}{27.5 \times 2000000}\right)} = \cdot 654083 \text{ nearly.}$$

In this case, therefore, the area of each circumpolar continent would be a little more than a sixth of the area of the entire surface. If $\frac{\delta}{a} = \frac{1}{566.95}$, or if the mean depth of the ocean were 7.055 miles, no circumpolar continents would exist. All authorities, however, appear to concur in thinking that so great a mean depth cannot be attributed to the ocean, but, on the contrary, that it must be, at most, some small fraction of the earth's ellipticity. It follows that if the earth were originally spherical, two great circumpolar continents, with an intermediate equatorial ocean, should necessarily exist. If, in accordance with the assumptions of the theory, the forces tending to transport water towards the equator were more effective than those tending to transport matter towards the

poles, the areas of the circumpolar continents would be continually lessening, and at the same time the entire mass would tend to assume the figure of an oblate spheroid. Hence, if any land should exist at the equatorial regions due to small irregularities in the earth's surface, the ratio of its area to that of the circumpolar land would, up to a certain limit, be continually increasing. This conclusion is confirmed by that at which Playfair has arrived in his Illustrations of the Huttonian Theory,* although we cannot implicitly confide in the accuracy of his numerical results, as he has not exhibited the successive steps of his investigation."

Mr. Donovan read the first part of a paper " On the universal Vitality of Matter, and its Exaltation into animal and vegetable Life."

The opinions of the ancient philosophers on this subject were referred to, and it was shown that the vitality of matter was maintained as a fundamental principle in the most celebrated of the schools of antiquity, and that it has been accredited by many in modern times. The author then explained that he was far from attributing to matter any vitality of the kind possessed by animals or even vegetables; and showed that it is possible to conceive the existence of some of the properties of life in matter, along with a capability of conjunction with others, when circumstances favourable to such a change are present. Examples of this kind were given. He adduced instances in which, by the successive abstraction of properties, vitality of the most exalted character was gradually degraded to the lowest kind of inorganic life. Abstracting from all consideration of an immortal spirit which belongs to man alone, it was shown that life and death are merely relative; that many properties of life are discoverable in death ; that life may be simulated by death, and death by life ; and processes were re-

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* Works, vol. i. p. 489.